GP37156 ©

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
21 May 2004 (21.05.2004)

PCT

(10) International Publication Number
WO 2004/042646 A1

(51) International Patent Classification[7]: G06K 9/00, G07C 9/00

(21) International Application Number: PCT/NL2003/000772

(22) International Filing Date: 5 November 2003 (05.11.2003)

(25) Filing Language: Dutch

(26) Publication Language: English

(30) Priority Data:
1021847 5 November 2002 (05.11.2002) NL

(71) Applicant (*for all designated States except US*): **JOH. ENSCHEDE B.V.** [NL/NL]; Jan Van Krimpenweg 15a, NL-2031 CE Haarlem (NL).

(72) Inventor; and
(75) Inventor/Applicant (*for US only*): **KOOMEN, Jacob** [NL/NL]; Boterbloem 9, NL-1902 GN Castricum (NL).

(74) Agent: **DE HOOP, Eric**; c/o Octrooibureau Vriesendorp & Gaade, P.O. Box 266, NL-2501 AW The Hague (NL).

(81) Designated States (*national*): AE, AG, AL, AM, AT (utility model), AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ (utility model), DE (utility model), DK (utility model), DM, DZ, EC, EE (utility model), EG, ES, FI (utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK (utility model), SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (*regional*): ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:
— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for the following designations AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM,*

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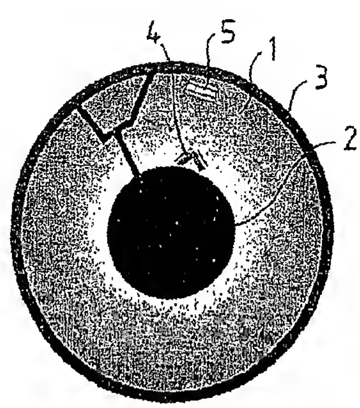
(54) Title: IRIS DETECTION



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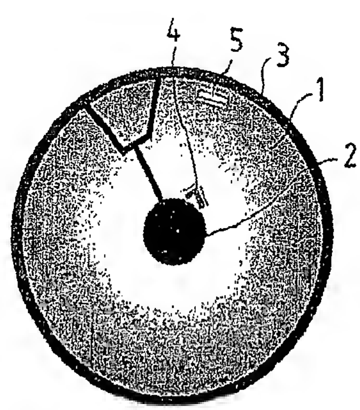

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WO 2004/042646 A1

(57) Abstract: The invention relates to a method for iris detection, comprising capturing a first image registration of an iris at a first point in time and within a time window of several minutes at the most around the first point in time capturing a second biometric characteristic, and a device for this purpose. The method is used for determining whether an eye is real, that means live, or whether an attempt at fraud is being made.

PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)

Published:

— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

IRIS DETEKTION

The invention relates to a method and a device for iris detection, and particularly for recognising attempts at fraud in iris identification.

In practice iris identification is used as a simple method to verify the identity of a person. However, it has appeared that it is relatively easy to commit fraud. This problem is extensively described in among others WO-A1-01/01329 and US-B1-6.247.813.

US-B1-6.247.813 describes the fact that a pupil responds to changes in light intensity. It is suggested in the US patent specification to use the pupil's response time to changing illumination for testing on drug use, alcohol use or medicine use. The response time of the iris namely changes under the influence of drugs or medicine. No description is given of whether an iris is recognized as real or whether it regards an attempt at fraud.

WO-A1-01/01329 describes several ways to render attempts at fraud in iris identification impossible, such as the use of polarised light, "red eyes" detection and measuring surface curvature.

EP-A2-1.139.301 describes a device and method for person identification by means of recording several biometric images. Images are captured of for instance an iris, finger prints, hands, et cetera. To that end the device in one embodiment is provided with an image recorder which synchronously to a stroboscopic illumination unit records images of an iris with a reduced pupil.

The testing for attempts at fraud in iris identification, particularly recognising whether an eye is a real eye, however, remains a problem.

It is an object of the invention to at least partially overcome the drawbacks mentioned.

To that end the invention provides a method for iris detection, comprising capturing a first image registration of an iris at a first point in time and within a time window of several minutes at the most around the first point in time capturing a second image registration of the iris, wherein the light intensity on the iris to be measured is changed more than a pupil reaction time prior to the second image registration and whether stretch of the tissue of the iris has taken place is determined from the first and second image registration.

By carrying out a second measurement shortly after the first image registration of the iris it has appeared to be possible to reduce the chances of fraud and thus improve iris identification. Particularly the capturing of the determination shortly after one another, renders it very difficult, if not impossible, to a fraud to commit fraud. The second determination is not used to reduce the chances of errors, but to verify whether the iris identification is based on measurements on a real eye. In this way iris identification can be made considerably more reliable, by means of a very small adjustment to the existing equipment. In the invention the stretch of the tissue of the iris is determined from the first and second image registration. It has appeared that it is easy to commit fraud by means of for instance a contact lens. This attempt at fraud, as is explained below, cannot be detected by merely measuring the change in the pupil diameter.

In an embodiment of the method according to the invention a second biometric characteristic can be used. In an embodiment the second biometric characteristic is selected from the group comprising hand geometry, the retina, speech and the iris. Said characteristics can be easily and quickly determined, and due to their nature are particularly suitable to be carried out almost simultaneously with the measurement of an iris, and to be used to

establish the authenticity of an iris.

The second determination may for instance be a second image registration of the iris. It does not need further explanation that this is very simple to implement. However, it has appeared that such a second measurement offers particular possibilities to confirm the authenticity of an iris measured (earlier).

Particularly when the second image registration is captured at a light intensity that differs from the light intensity at the capturing of the first image registration, it has appeared that special possibilities are revealed. It is possible then to measure the change of the pupil, but what has turned out to be a more reliable method, to determine the stretch of the iris tissue.

A possibility to vary the light intensity is a method in which either prior to the first image registration or prior to the second image registration a light pulse is supplied on the iris. By experiment it has been established that a proper determination is obtained when the light pulse is either supplied or started in a time span of 0.2-1 seconds prior to a capturing.

It is preferred here in one embodiment, that the first and second image registration are captured shortly after one another, preferably within one minute, preferably within two seconds.

The strength of the light intensity change has to be established in experiments. However, to an expert in this field it will be clear that this change has to be sufficient to effect a pupil reaction. In addition this regards an intensity change of (ambient) light in the visual range or visible area, roughly between 400 and 700 nm. The image registration of the eye is captured in the infrared (IR) range. Considering the response of the eye to change it is of course also possible to offer a light intensity change, such as a light pulse, and immediately after that capture a first registration, within the pupil

response time, and a reaction time after the first registration, when the pupil has had time to respond, carrying out a second measurement. It will be clear that identity checks in general preferably have to be carried out as quickly as possible, and iris recognition can only result in a practical method when the procedure is quick, without problems and reliable. The procedure therefore has to be as quick as possible. It has appeared that a method that first offers a short-term light intensity increasing stimulus, carries out a first measurement prior to the pupil response time, and carries out a second measurement during the pupil response time, results in the quickest procedure. The entire measurement then need not take longer than 2-4 seconds, the first measurement will be carried out between the 200-600 milliseconds after the pulse. To that end a device for iris recognition comprises a first light source for emitting light in the visual range, recording means for capturing an image of an eye, control means for activating the first light source, and subsequently activating the recording means for capturing a first image registration within the eye response time and subsequently activating the recording means within the accommodation time of the pupil to a changing light intensity.

An embodiment of the method described above can be implemented in the following manner. A first image registration of an iris is captured here, the outer edge and the pupil edge of the iris are determined, the image registration is transformed into a first normalised iris image, wherein the iris image is normalised, the first normalised iris image is correlated to a second normalised iris image of an iris, a correlation value is calculated, and it is tested whether the correlation value is significant.

A further development thereof regards one wherein a first and second pupil diameter for the first and second iris image is determined, both pupil diameters are compared, and from the significance of the correlation value and of a pupil diameter change it is determined whether the iris tissue has stretched and, if such is not the case, whether for instance an attempt at

fraud is made. The attempt at fraud is not determined here from the pupil diameter change per se. It is namely tested whether there is question of stretch in the iris tissue. It is tested whether both images regard the same iris, and there is only question of a real eye, when that is on the condition that another pupil diameter was taken as starting point during the normalisation. In this way it is very simple to check whether an eye is a (real) life eye.

Another development is one wherein in the transformation of the iris image into a normalised iris image, the pupil diameter is varied and the correlation is maximised, in which at a maximum correlation both the pupil diameters and the correlation value are tested for determining whether stretch of the iris tissue has taken place, for instance for establishing whether an attempt at fraud is made.

In the method image registrations of an iris can be compared. It is also possible to determine characteristics from the iris images after normalisation and subsequently correlating the characteristics for determining a correlation value.

In addition the application relates to a device for iris detection, comprising an illumination unit for illuminating an iris, an image recorder for capturing an image of an iris, memory means for storing at least two image registrations of an iris, a data processing unit provided with software for converting the image registrations into normalised image registrations, correlating two normalised image registrations in which a correlation value is determined, and testing whether the correlation value is significant.

In one embodiment thereof the device is provided with an illumination unit provided with at least two switchable illumination states, the image recorder being connected to the illumination unit for setting the illumination state and capturing at least two images at at least two illumination states. The

illumination states may differ in light intensity, in extreme cases the switching on or off of for instance an (additional) illumination unit.

In an alternative embodiment it may regard a first illumination at a first angle, and a second illumination at a second angle, that means an angle to the line pupil-image recorder.

In a further development thereof the device is provided with a memory for storing an iris image, and the software is provided with a procedure for correlating and testing two images captured one after the other at two different illumination states, a decision function is present for determining whether an attempt at fraud is made, and comparing characteristics from a captured iris image with characteristics from the iris image from the memory.

The application furthermore relates to an assembly of a device as described above and a portable data carrier, particularly a chip card, wherein the data carrier is provided with data regarding biometric characteristics.

Particularly the data carrier is furthermore provided with personal details.

In a further development of such a device the software is adapted for deciding whether an attempt at fraud is made, and subsequently comparing an iris image with the iris image with associate personal details. In a simple implementation first characteristic properties are determined from an iris image. Subsequently said characteristic properties are correlated. Instead of the iris image itself the characteristic properties can be stored.

The invention further relates to a device for iris recognition, comprising an image recorder for capturing a first image of an iris and a second image of an iris, and means for determining the stretch of iris tissue from a comparison of the images.

In an embodiment thereof the means for determining the stretch of iris tissue comprise means for determining the pupil edge, means for determining the iris edge, means for transforming an iris image based on the determined pupil edge and the iris edge, means for correlating two images of an iris, or the characteristic properties of the iris that have been determined from the images of the iris.

The invention further relates to a method for verifying the identity of a person, wherein at a first point in time an image registration of the person's iris is captured, within a time window around the first point in time a second biometric characteristic of the person is measured, data regarding the iris and the person's second biometric characteristic are read from a portable data carrier of the person and compared with data determined from the image registration of the iris and the second biometric characteristic.

In one embodiment thereof the second biometric characteristic originates from a measurement of the retina, the voice or hand geometry.

When apart from the iris a second biometric characteristic of a person is captured, both can be tested against biometric information stored in a data base or portable data carrier. If both biometric characteristics match the stored biometric information associated with the same person, it can concluded that both biometric characteristics originate from the same person. If one of these biometric characteristics is not fraud-sensitive, then it follows from the fact that both biometric characteristics match, that no fraud was committed with the other biometric characteristic.

A biometric characteristic is not fraud-sensitive when it is difficult to "steal". A registration of the retina is very difficult to capture from a person who is unwilling to cooperate. This also applies to hand geometry. These two examples are in contrast to finger prints that every body leaves unwittingly on any touched object and which for that reason can be copied easily and

unnoticed.

Another reason why a biometric characteristic cannot be considered fraud-sensitive, is that every manifestation of the biometric characteristic is different, so that a registration beforehand is not useful. This is for instance the case in so-called "challenge-response" systems: the system asks the person for instance to pronounce a sentence. This sentence is different every time. The person repeats the sentence and the systems tests whether this is the correct sentence and also whether the biometric characteristics of the speech correspond to this person.

By coupling iris biometry to a second biometric characteristic, fraud detection can be carried out with the second biometric characteristic. The achievement rates of this second biometric characteristic (false reject rate and false accept rate) thus become the achievement rates of the live-detection. The identification can remain to take place by means of the iris recognition as it has the best achievements to this end. The reliability of the identification in this arrangement therefore is not influenced by the second biometric characteristic, this as opposed to systems that combine biometry to attempt to come to an improved identification.

In addition the invention relates to a device for iris detection, comprising an image recorder for capturing an iris image in an image plane, a first illumination unit for illuminating the eye at a first illumination angle between 10 and 80 degrees with respect to a connecting line of the pupil to the image recorder, and a second illumination unit for illuminating the eye at a second illumination angle, the angle included by the second illumination unit, the pupil and the first illumination unit being smaller than 180 degrees.

The invention further relates to a method for iris detection, wherein a first iris image of an eye is captured while the eye is being illuminated at a first illumination angle, a second iris image is captured at a second illumination

angle which is different from the first illumination angle, the clarity change of the white of the eye is determined from the first and second iris image, after which the clarity change of the eyeball of which the iris images have been captured is compared with the predetermined clarity change of a life eyeball.

In this way it is simple to detect whether there is question of a life eye. Use is made of the establishment that the eye is a so-called Lambertian diffuser. Such a method is furthermore easy to integrate in existing equipment.

The captured image is built up from image elements. The value of an image element corresponds to the intensity of the reflected light on the corresponding location of the object (the eye). Said perceived intensity is proportional to the reflection coefficient of the object, the intensity of the light source and depends on the orientation of the object plane with respect to the light source. The captured image therefore contains information about the spatial structure (orientation of the object plane) of the eye. This information however is mixed with the other factors mentioned, namely illumination and reflection factor. If we take at least two images of the same object, the images being illuminated from a different direction, the influence of the reflection factor can be eliminated. In all images the perceived intensity of a perceived object point namely is proportional to the reflection factor, so that the ratio (or another function, which only depends on the ratio) of the image intensity of the image elements corresponding to the same object point only depend on the illumination and the spatial orientation.

In an embodiment hereof the illumination is constant over the entire object, so that the relation of said image elements only depends on the spatial orientation. In other cases the influence of the illumination can be determined beforehand, so that the influence of the spatial orientation also becomes known. The knowledge of the spatial orientation means concretely that at points corresponding to for instance the white of the eye it can be established whether these points are located on a sphere or on a flat surface.

The system is thus able to make a distinction between a normal eye and a picture of an eye. In addition it appears from the image points corresponding to the iris whether these points are located on a flat surface or on a curved surface. As a normal iris is predominantly flat and the print of a contact lens follows the curvature of the cornea, the system is thus able to detect whether the iris is flat, as usual, or covered by a printed contact lens. By means of this method the system is able to detect and prevent fraud with pictures and contact lenses.

In an embodiment the invention relates to software for iris detection, comprising an iris stretch routine for determining from two image registrations of an iris whether tissue of the iris has stretched. Such software makes it possible to have an iris detection device operate according to the method of the invention.

In one embodiment of the software the iris stretch routine comprises: an iris image normalisation routine for normalising an image registration of an iris in which the pupil diameter is a variable; a correlation routine for calculating a correlation of at least two normalised image registrations of an iris, and an optimisation routine for optimising the correlation, having the pupil diameter as set variable.

In addition the software comprises an illumination operating routine for switching the illumination on and off and coordinating it with the points in time of the first and second image registrations.

It will for that matter be clear that if so desired more than two image registrations can be captured, if so desired each at another light intensity.

The invention will be elucidated on the basis of an exemplary embodiment of a device and a method for iris identification according to the invention, in which:

Figure 1 shows an iris image at a first light intensity;

Figure 1B shows a measurement of the same iris at a higher light intensity than in figure 1A,

Figure 2A shows a measurement of an artificial eye at the first light intensity;

Figure 2B shows a measurement of the artificial eye of figure 2A at the second light intensity;

Figure 3A shows a measurement of an eye provided with a printed contact lens at the first light intensity;

Figure 3B shows a measurement of the eye of figure 3A at the second light intensity;

Figure 4 shows a device for iris recognition and iris detection according to one aspect of the invention.

Figure 1A shows an image registration of an eye having an iris 1. The illumination was set here at a first level. In the image registration various parts are indicated, such as the pupil edge 2 and the outer edge of the iris 3. Moreover a first characteristic 4 and a second characteristic 5 have been indicated that are specific to this iris in question.

In figure 1B a second image has been captured of the same iris, but now at a higher light intensity. The registration can also have been captured just after a light pulse. Due to the changing light intensity the pupil will contract. It has appeared that the iris tissue stretches along in a specific manner. The position of the characteristic 4 that is situated near the pupil edge remains situated near the pupil edge. The position of the characteristic 5 that is

situated near the iris edge will also remain situated there. Characteristics situated in between them will be moved depending on the distance to both edges. It has been established that first of all as the characteristics are situated closer to the pupil edge the absolute position changes more. In addition it has been established that the relative position in a system of coordinates having the pupil edge and the iris edge as reference points, does not change or hardly changes. This establishment has made it possible to recognise a life eye, as will be explained on the basis of two known attempts at fraud. First of all fraud using an artificial eye is discussed in figures 2A and 2B, and the fraud using a printed contact lens is discussed in figures 3A and 3B.

In figure 2A a measurement is shown of an artificial eye at the same light intensity as in figure 1A. In the figure the same parts are shown as in figure 1A. In figure 2B the same measurement is repeated, but now at the second light intensity. It can be seen that the eye does not change. The pupil diameter is unchanged. Measurement of the pupil diameter would therefore appear to be sufficient to expose an attempt at fraud.

In figure 3A the measurement of figure 1A is repeated, but now with an eye provided with a printed contact lens. In figure 3B the measurement of figure 1B is repeated with the eye of figure 3A. It can clearly be seen that now the pupil diameter does change. In this attempt at fraud the detection of change in the pupil diameter can be circumvented. However it can also be seen that the absolute position of characteristic 4 has remained the same but the relative position with respect to the pupil edge has not. By also comparing the relative position of the characterising parts of an iris of two images, it is simple to establish whether it regards a life eye or an attempt at fraud. In fact the stretch of the iris tissue is measured.

The mere determination of the change of the pupil diameter therefore has proven not to be sufficient to determine whether the eye offered is a life eye.

There are several methods possible to use the above-mentioned establishment for recognising a life eye.

Figure 4 shows a device for iris identification 11 according to an aspect of the invention. An image recorder 12 provided with a semitransparent mirror is placed in the centre. Above the image recorder a first illumination unit 14 is accommodated which emits light in the visual range or visible area. In this embodiment a series of LEDs has been opted for. Below the image recorder 12 an infrared light source 13 has been accommodated as second light source. The image recorder 12 captures an image in the infrared (IR) range.

The operation is as follows. A person who for instance wants access or otherwise wishes to be identified looks into the mirror of image recorder 12. As a result one of his eyes is positioned in the image plane. The first illumination source 14 is switched on very briefly, as a result of which the light intensity in the image plane becomes higher. Immediately or simultaneously a first image registration is captured while the second illumination source is switched on. Shortly after that the pupil responds by contracting. A second registration is captured at the moment that the pupil is contracted or has reached its minimum size. Usually between the 0.5-3 seconds.

Determining equality

If we want to establish whether one measurement value is equal to another measurement value, we can examine whether both measurement values have an equal value (whether their difference is zero). If the measurement has taken place without any disruptive influences this is a satisfactory method. However, as soon as deviations occur the question arises: "is this deviation significant?". A real deviation will not become apparent until it is larger than the measurement accuracy. On the other hand the measurement inaccuracy may also hide a real deviation. The optimal decision point can be

derived from the test material.

In order to determine whether two recorded signals are observations from the same source, a simple comparison will in general not suffice. The registration process may influence the recorded signal. If said influence is linear then there is a linear connection between the two recorded signals, if they indeed originate from the same source. This situation often occurs for instance in sound registrations having different amplifier settings, or image registrations having a different illumination. In case of a linear connection, the correlation coefficient is a good standard for equality of the source signal:

$$C_{xy} = \sigma_{xy} / \sqrt{(\sigma_{xx} \bullet \sigma_{yy})} \; ;$$

(1)

with

σ_{xy} = covariance: $E\{(x-\mu_x) \bullet (y-\mu_y)\}$ and

μ_x = average: $E\{x\}$

when

$$y = ax + b$$

applies:

$\sigma_{xy} = a \bullet \sigma_{xx}$ and

$\sigma_{yy} = a^2 \sigma_{xx}$

so that:

$$C_{xy} = \sigma_{xy} / \sqrt{(\sigma_{xx} \bullet \sigma_{yy})} = a \bullet \sigma_{xx} / \sqrt{(\sigma_{xx} \bullet a^2 \sigma_{xx})} = a / \sqrt{a^2} =$$

sign (a) = ± 1

If y is not correlated to x, σ_{xy} and thus C_{xy} will go to zero.

A practical question that occurs often is: "does basis signal Y occur in the registration X". X is measured at a certain position or at certain point in time signal Y can occur with a certain strength together with other phenomena. For instance echo in a sonar signal, a transmitted bit over a modem line or a contrast transition in a digital image registration. In this case the correlation coefficient between the registration X and any possible shift/delay of the basis signal Y has to be determined. The correlation is determined as a function of the shift or delay. This is known as the cross-correlation R_{xy}:

$$R_{xy}(\tau) = E\{ x(t)y(t-\tau) \}$$
(2)

The cross-correlation standard is also known as "template matching" or "matched filtering". The cross-correlation can also be described as signal (or image) filter, in which the filter core corresponds to the basis signal. This form of filtering is called "optimal filtering" and in case of normally distributed interference results in a signal having an as large as possible signal to noise ratio.

For purposes of detection it is easier to scale the cross-correlation, in correspondence with the correlation coefficient:

$$C_{xy}(\tau) = E\{ (x(t) - \mu_x) \bullet (y(t-\tau) - \mu_y)\} / \sqrt{(\sigma_{xx} \bullet \sigma_{yy})}$$
(3)

or in case of a two-dimensional signal, such as an image registration:

$$C_{xy}(\tau, \upsilon) = E\{ (x(u,v) - \mu_x) \bullet (y(u-\tau, v-\upsilon) - \mu_y)\} / \sqrt{(\sigma_{xx} \bullet \sigma_{yy})}$$
(4)

The previous problem

"Does a *shifted* version of the basis signal Y occur in the registration X"

can be made more general into:

"Does a *transformed* version of the basis signal Y occur in the registration X".

Said transformation may be: a linear transformation, a translation, a rotation, out-of-focus or other (geometric) transformations. The transformation is called **G**. It is determined by a transformation model and a set of parameters ***p*** (for instance translation vector, angle of rotation, et cetera). The model determines what transformation will be taken into consideration. The transformed basis signal then is **G** (y(u,v);***p***).

Again the correlation can be calculated for each transformation within our model:

$$C_{xy}(\boldsymbol{p}) = E\{ (x(u,v) - \mu_x) \bullet (\mathbf{G}(y(u, v);\boldsymbol{p}) - \mu_{G(y(u,v);p)})\} / \sqrt{(\sigma_{xx} \bullet \sigma_{G(y)G(y)})}$$
(5)

It will be clear that any degree of freedom in the transformation G will render the calculation of the correlation function one order more difficult. In practical uses as many model parameters as possible will be estimated beforehand, and only be correlated over the domain of parameters that cannot be predicted.

This general problem can also be formulated slightly differently as:

"Are the images X and Y transformed versions of the same basis signal"

In this case a uniform description for both images is looked for. The transformation may be different for both images. The basic model describing the transformation, however, is the same. We are therefore looking for those transformation, that bring both images into conformity as much as possible. The correlation between the transformed images subsequently indicates how well the images can be brought into conformity:

$$C_{xy}(\boldsymbol{p}_x, \boldsymbol{p}_y) = E\{(\mathbf{G}(x(u,v); \boldsymbol{p}_x) - \mu_{(G(x(u,v);p))} \bullet (\mathbf{G}(y(u,v); \boldsymbol{p}_y) - \mu_{G(y(u,v);p)})\} / \sqrt{(\sigma_{G(x)G(x)} \bullet \sigma_{G(y)G(y)})} \quad (6)$$

Application on iris images

In an image registration of the iris, the iris tissue is depicted on a series of image elements (pixels). The image elements show the transformed version of the iris tissue. This depiction is (among others) influenced by the following parameters:

- camera angle:

  diaphragm influence on the definition of the image and the light intensity on the image sensor

  zoom influence on the magnification factor

  focusing influence on the definition of the image

  lens aberrations cause non-linear geometric deformation and loss-of-focus

- position of the iris with respect to camera: 6 degrees of freedom:

position (x,y,z) influence on position in image, magnification factor and definition

angles of rotation of iris in the image registration or iris circle are depicted as ellipse

- illumination influence on light intensity on image sensor
- pupil size influence on stretch condition of the iris tissue
- covering by eyelids and reflection makes parts of the iris tissue invisible
- light deflection by cornea (and possibly spectacles or contact lens)

  causes non-linear geometric transformation of iris tissue on image sensor
- image sampling screen (resolution)

  influence on magnification factor. Magnification factor may differ in x and y direction.
- relation light intensity < > pixel value

  setting of video analogous-digital convertor,

  sensitivity image sensor
- noise

  noise in image sensor, video enhancement, but also mirroring light reflection of the cornea.

In order to describe the iris as a surface having varying reflection, use can best be made of a local system of coordinates. The origin then lies in the centre of the pupil and in the plane of the iris. The tissue surface can now be described as a function of two variable (r, φ) in which the radius runs from pupil edge to iris edge and the angle runs from 0 to 2^{π} radials. Preferably a normalised radius value is used here, having value 0 on the pupil edge and value 1 on the iris edge.

The transformation G ($\bullet$; $\boldsymbol{p}$) of this normalised iris surface $I_n(r, \varphi)$ into the image registration contains the following elements:

INTERNATIONAL SEARCH REPORT

PCT/NL 03/ 00772

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G06K9/00 G07C9/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G06K G07C A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 139 301 A (MATSUSHITA ELECTRIC IND CO LTD) 4 October 2001 (2001-10-04) cited in the application column 2, line 35 - line 43 column 13, line 11 - line 16 column 17, line 46 - line 56 column 11, line 50 -column 12, line 15 ---	1-18,24, 25,29,30
X	US 5 291 560 A (DAUGMAN JOHN G) 1 March 1994 (1994-03-01) column 6, line 38 - line 61 -----	1,2,13, 29,30

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 February 2004	26/02/2004

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Sonius, M

INTERNATIONAL SEARCH REPORT

PCT/NL 03/ 00772

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